

# **FY 2018 MAPP Program Information Sheet**

The mission of the Modeling, Analysis, Predictions, and Projections (MAPP) Program is to enhance the Nation's capability to predict variability and change in Earth's climate system. The MAPP Program focuses on the coupling, integration, and application of Earth System models and analyses across NOAA, among partner agencies, and with the external research community. Primary objectives include: 1) improving Earth System models; 2) supporting an integrated Earth System analysis capability; 3) improving methodologies for global to regional scale analysis, predictions, and projections; and 4) developing integrated assessment and prediction capabilities relevant to decision makers based on climate analyses, predictions, and projections.

## **FY 2018 Competitions**

In FY 2018, the MAPP Program is soliciting proposals for the following three competitions:

- Advancing Earth System Data Assimilation
- Addressing Key Issues in CMIP6-era Earth System Models
- NOAA Climate Test Bed - Advancing NOAA's Operational Subseasonal to Seasonal Prediction Capability

Individual proposals may target only one competition, which must be clearly identified in the proposal summary. Details regarding the MAPP Program FY 2018 competitions are given below.

---

### **Competition 1: Advancing Earth System Data Assimilation**

NOAA is moving toward a unified modeling approach to support prediction of extreme weather and its associated drivers at extended time ranges<sup>1</sup>. A key aim is to harness predictability sources across scales present in the Earth system. Strongly coupled data assimilation (DA), where observations in one component of the Earth system are allowed to directly impact the state estimation in other components, may help to advance subseasonal-to-seasonal prediction through improved model initialization<sup>2</sup>. It also may improve reanalyses for Earth system monitoring and prediction uses<sup>2</sup>. However, the optimum approach(es) to coupled DA in the context of Earth system modeling and prediction is an open research question, and thus represents a major research need for NOAA.

Additionally, improved DA for individual Earth components such as the cryosphere, ocean, waves, land surface, and atmospheric composition is critical to better monitoring Earth system variability across all time scales. NOAA services span all these Earth system disciplines and would greatly benefit from improved monitoring products. The U.S., and specifically NOAA, have significant investments in Earth observations to be leveraged for this purpose. For example, quality controlled in situ and new remotely

---

<sup>1</sup> "High-level NOAA Unified Modeling Overview" white paper (2017):

[ftp://ftp.library.noaa.gov/noaa\\_documents.lib/NOAA\\_UMTF/UMTF\\_overview\\_2017.pdf](ftp://ftp.library.noaa.gov/noaa_documents.lib/NOAA_UMTF/UMTF_overview_2017.pdf)

<sup>2</sup> NAS NRC Report: Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts (2016): <https://www.nap.edu/read/21873/>

sensed datasets from the Joint Polar Satellite System (JPSS) and GOES-R have recently become available<sup>3</sup> that may be well suited for assimilation.

The MAPP Program has previously supported DA and new techniques for reanalysis as part of its core mission. In FY 2018, the MAPP Program, in partnership with the National Weather Service (NWS) Office of Science and Technology Integration (OSTI) Next Generation Global Prediction System (NGGPS) and National Environmental Satellite, Data, and Information Service/JPSS Center for Satellite Applications and Research (STAR) Programs, seeks to advance this priority by soliciting proposals targeting one of two objectives:

1) Develop a new methodology, or significantly advance an existing methodology, for coupled DA with demonstrable relevance to the Earth system prediction and/or monitoring needs of one or more NOAA Line Offices. Proposals must include a plan with appropriate metrics and benchmarks to compare against existing DA techniques. Investigators should strive to work within a unified DA framework and connect with the incipient Joint Center for Satellite Data Assimilation (JCSDA) Joint Effort for Data Assimilation Integration (JEDI)<sup>4</sup> as feasible. The team of proposers must include investigators from multiple institutions, with a mix of PIs from universities and NOAA Office of Oceanic and Atmospheric Research Federal labs strongly encouraged.

2) Develop new or experimental DA-based approaches to monitoring products for the cryosphere, ocean, land surface, or atmospheric composition. Proposals are required to involve a NOAA investigator or collaborator and to demonstrate relevance of intended new products to one or more NOAA Line Offices. Investigators are encouraged to include in their project the assimilation of climate-quality NOAA data and, specifically, reprocessed satellite-based products available from JPSS and associated NOAA archives and data repositories containing these satellite data/products<sup>3</sup>. New data from the JPSS series, beginning with the Suomi National Polar-orbiting Partnership launched in 2011, are providing key global datasets for consideration. Proposals should include evidence that the observational dataset(s) to be used are available and suited for the intended monitoring application, and describe how the product will be evaluated and validated. Proposals to develop JPSS datasets are outside the scope of the competition.

Team proposals targeting objective 1 may request funding at a level of up to \$500k/year for up to 3 years. Projects targeting objective 2 may be funded at a level of up to \$170k/year for up to 3 years.

#### **Competition Contact Information:**

MAPP Program Competition Manager: Heather Archambault ([heather.archambault@noaa.gov](mailto:heather.archambault@noaa.gov))

NGGPS Program Manager: Frederick Toepfer ([frederick.toepfer@noaa.gov](mailto:frederick.toepfer@noaa.gov))

JPSS STAR Program Manager: Lihang Zhou ([lihang.zhou@noaa.gov](mailto:lihang.zhou@noaa.gov))

---

<sup>3</sup> [https://www.star.nesdis.noaa.gov/jpss/documents/meetings/2017/JPSS\\_CPO\\_MAPP/JPSS\\_CPO\\_MAPP\\_REPORT.pdf](https://www.star.nesdis.noaa.gov/jpss/documents/meetings/2017/JPSS_CPO_MAPP/JPSS_CPO_MAPP_REPORT.pdf)

<sup>4</sup> <https://ams.confex.com/ams/97Annual/webprogram/Paper315326.html>

## Competition 2: Addressing Key Issues in CMIP6-era Earth System Models

Models including coupling among various Earth system components are increasingly the basis for predictions from days to decades at NOAA<sup>5</sup> and across the National modeling community<sup>6,7</sup>. These models are affected by biases that impact the fidelity of simulations and the skill of derived predictions across timescales. In fact, biases found in long-term simulations often arise at the weather timescale, within a few days of simulation. To improve model capabilities, it is crucial to identify and address the sources of model bias across NOAA's modeling suite. This involves understanding the source of the biases such as issues in models' physical process representation, model component interaction, and/or numerical approach, via a systematic process-oriented evaluation of the biases. To this end, the MAPP Program has been supporting community-based approaches to improve NOAA models via the development of process-level metrics and an open-source framework, an effort spearheaded by the MAPP Model Diagnostic Task Force<sup>8</sup>.

The Coupled Model Intercomparison Project (CMIP)<sup>9</sup> initiative offers a coordinated community-wide opportunity for model intercomparison, benchmarking, and improvement. The sixth CMIP experiment (CMIP6) is currently underway, and is organizing the production of a core set of model experiments of past and 21st century climate as well as a number of process and phenomenologically-focused Modeling Intercomparison Projects (MIPs). A major overarching scientific question for the CMIP6 experiment, key to making strides in NOAA model improvement, is "What are the origins and consequences of systematic model biases?"<sup>10</sup> Process-level evaluation of the CMIP6 models in comparison with observations, with targeted development of process-oriented metrics that provide insight into the sources of model bias beyond what performance metrics can provide, will greatly contribute to advancing NOAA models.

In FY 2018, the MAPP program is soliciting proposals that address key issues in the representation of Earth system processes in CMIP6-era models to improve model fidelity, focusing on select processes relevant to one or more of the following research areas:

- A. Cryosphere
- B. Weather and climate extremes, including drought
- C. Sea level and coastal dynamics

Cloud and radiative processes are major sources of model bias, are of relevance across the above focus areas, and could serve as focusing areas for proposed work. In addition, modeling of the Arctic region, an area undergoing change with both local and remote consequence is of particular interest.<sup>11</sup>

Projects selected via this solicitation are expected go beyond diagnostic evaluations of model performance, to evaluate processes relevant to one or more of the above areas using the CMIP6 data<sup>12</sup>. Proposed work should develop and apply process-oriented metrics to enhance a process-oriented

---

<sup>5</sup> [https://www.weather.gov/sti/stimodeling\\_nggps\\_implementation](https://www.weather.gov/sti/stimodeling_nggps_implementation)

<sup>6</sup> <http://espc.oar.noaa.gov/>

<sup>7</sup> <https://www.nap.edu/read/21873/>

<sup>8</sup> <http://cpo.noaa.gov/mapp/mdtf>

<sup>9</sup> <http://cmip-pcmdi.llnl.gov/>

<sup>10</sup> Eyring, V., Bony, S., Mehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., and Taylor, K. E.: Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, *Geosci. Model Dev.*, 9, 1937-1958, doi:10.5194/gmd-9-1937-2016, 2016.

<sup>11</sup> <https://www.nap.edu/catalog/21717/arctic-matters-the-global-connection-to-changes-in-the-arctic>

<sup>12</sup> <https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6>

framework approach to discriminate and better understand the sources of bias in the models. Based on CMIP6 data, projects should develop a clear assessment of pathways for model improvement, and should examine the ways in which resolution, model formulation, model components, and ensembles relate to the ability of the models to faithfully simulate the Earth system and its variability. Model improvements should be physically- and observationally-based, and be applicable across a variety of models to ensure robustness. Proposals should leverage publicly-available observational process data and observational resources such as Obs4MIPs<sup>13</sup>. Targeted experiments that extend the CMIP6-based evaluation for the improvement of models, particularly NOAA coupled models, may also be proposed. Proposed projects should have the overall aim to advance understanding of biases generally affecting CMIP6-era models and to identify targeted model improvements that can improve model fidelity. The expected outcome of funded projects is a clear understanding of the sources of model biases across the CMIP6 suite and viable pathways for improving the models.

To address the above research areas, projects should use the Diagnostic, Evaluation, and Characterization of Klima (DECK) experiments<sup>14</sup> as well as relevant MIPs that leverage the structure and organization provided by the CMIP umbrella.<sup>15</sup> Among the MIP experiments that may be useful to address the goals for this solicitation are: Flux-Anomaly-Forced MIP (FAFMIP), High-Resolution MIP (HighResMIP), Land Surface, Snow and Soil Moisture MIP (LS3MIP), and Sea Ice MIP (SIMIP), Radiative Forcing MIP (RFMIP), Cloud Feedback MIP (CFMIP), Ice Sheet MIP (ISMIP6), and the Ocean Model MIP (OMIP)<sup>16</sup>. If using data from a particular MIP experiment, the proposal should demonstrate that this data is expected to be available at a time in line with the proposed project work plan. Additional model datasets outside of the CMIP6 framework may be used to accentuate the proposed evaluation and development activities. These can include existing public model datasets, or model experiments described in the proposal and carried out as part of the project activities.

The process-metrics framework<sup>17</sup> designed by the MAPP Diagnostics Task Force provides a useful context for new metrics developed under this solicitation. Proposals should plan to contribute new process-oriented metrics to the open framework, to apply the evaluation framework to the CMIP6 models, or to expand the use of the evaluation framework through relevant collaborations with modeling centers, research groups, and evaluation efforts such as NOAA's National Centers for Environmental Prediction, DOE's Accelerated Climate Modeling for Energy, DOE Ultrascale Visualization Climate Data Analysis Tools, etc.

Individual projects that address select processes relevant to one or more of the above research areas A-C may be funded at a level of up to \$170 k/year for up to three years. A team proposal of up to \$500 k/year for up to three years is also solicited. The team proposal should address research areas A-C above and advance key objectives of this solicitation, including the process-oriented model diagnostics framework initiated by the MAPP Model Diagnostics Task Force. The team proposal should also describe plans for how to integrate results and activities of the individual projects in a Task Force collectively and synergistically addressing the core scientific objectives of this solicitation. These will include a vision for collaborative activities to unify participating researchers, an infrastructure for data and code sharing, a

---

<sup>13</sup> <https://www.earthsystemcog.org/projects/obs4mips/>

<sup>14</sup> <http://www.geosci-model-dev.net/9/1937/2016/>

<sup>15</sup> Data for the DECK experiments is expected to become available starting in 2017 while data from the MIPs is expected to become available in 2018 and beyond.

<sup>16</sup> These experiments are described in papers in this Geoscientific Model Development special collection: [http://www.geosci-model-dev.net/special\\_issue590.html](http://www.geosci-model-dev.net/special_issue590.html)

<sup>17</sup> [http://cpo.noaa.gov/sites/cpo/MAPP/pdf/MDTF\\_API.pdf](http://cpo.noaa.gov/sites/cpo/MAPP/pdf/MDTF_API.pdf)

methodology to engage researchers in model evaluation and development activities, and plans for publications or other documentations that can synthesize and disseminate the work of the Task Force.

**Competition Contact Information:**

MAPP Program Competition Manager: Daniel Barrie ([daniel.barrie@noaa.gov](mailto:daniel.barrie@noaa.gov))

---

### Competition 3: NOAA Climate Test Bed - Advancing NOAA's Operational Subseasonal to Seasonal Prediction Capability

NOAA's operational prediction efforts are a core part of NOAA's mission to support economic vitality and protect American lives and resources. As part of NOAA's research Line Office, OAR, the MAPP program supports research and its transition into improved operational capabilities, products, and services. MAPP supports research to improve the NWS National Centers for Environmental Prediction (NCEP) Climate Prediction Center's operational products in part by partnering with NCEP to support the Climate Test Bed<sup>18</sup> to test and demonstrate the potential for scientific advances from the community external to NCEP to improve operational climate predictions. MAPP provides support for testing and demonstration research phases, whereas NCEP provides support for the operational implementation phase.

In FY 2018, the MAPP Program, in partnership with the NWS/OSTI/NGGPS Program, is soliciting proposals involving the external community to advance the Climate Prediction Center's subseasonal to seasonal prediction capabilities via the Climate Test Bed. Research projects should focus on one or both of the following areas:

1. Testing and demonstration of an experimental prediction methodology (e.g. new calibration or post-processing techniques, verification techniques) or system (e.g., experimental multi-model combinations, hybrid statistical/dynamical systems, merging of systems across timescales to advance subseasonal prediction) developed in the broader community for operational purposes. Projects seeking to improve the prediction of extremes such as heat waves or heavy precipitation are encouraged.
2. Improving multi-model ensemble prediction systems such as the North American Multi Model Ensemble (NMME<sup>19</sup>) by testing and demonstrating the utility of new or higher-resolution models, improved forecast initialization practices, or upgrades to other aspects of the system.

Within each research area, proposals can elect to focus on specific aspects listed above. Projects should demonstrate relevance to strategic programmatic and agency directions<sup>20</sup>. Proposed work may consider testing and demonstrating improvements for prediction systems, techniques, or products that are already operational, or are being experimented with for operations.

To be eligible for the Climate Test Bed, projects must have a beginning Readiness Level (RL) of 5-8 (please see Appendix for RL definitions). **A transition plan signed by the NWS and OAR Assistant Administrators, or their designees, must be submitted with the proposal.** Please see NOAA Administrative Order NAO 216-105B<sup>21</sup> (section 3.06) and the accompanying procedural handbook<sup>22</sup>

---

<sup>18</sup> <http://www.cpc.ncep.noaa.gov/products/ctb/>

<sup>19</sup> <http://cpo.noaa.gov/mapp/nmme>

<sup>20</sup> <http://cpo.noaa.gov/AboutCPO/CPOStrategicPlan.aspx>;  
<http://research.noaa.gov/AboutUs/OurStrategicPlan.aspx>;  
[http://www.ncep.noaa.gov/director/strategic\\_plan/strategic\\_plan.pdf](http://www.ncep.noaa.gov/director/strategic_plan/strategic_plan.pdf)

<sup>21</sup>

[http://www.corporateservices.noaa.gov/ames/administrative\\_orders/chapter\\_216/NAO%20216-105B%20UNSEC%20Signed.pdf](http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_216/NAO%20216-105B%20UNSEC%20Signed.pdf)

<sup>22</sup>

[http://www.corporateservices.noaa.gov/ames/administrative\\_orders/chapter\\_216/Handbook\\_NAO216-105B\\_03-21-17.pdf](http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_216/Handbook_NAO216-105B_03-21-17.pdf)

(Chapter 2, section D) for information on preparing a transition plan. Proposals must comply with all requirements for Climate Test Bed proposals<sup>23</sup> by demonstrating high relevance to operational prediction, including an NCEP co-PI or collaborator on the proposal, having explicit support from NCEP to access required data and models, and using NCEP's metrics for evaluation<sup>24</sup>.

At the end of the project, an NCEP-CPO review will assess the feasibility of a transition of the project into operations. Therefore, the transition plan must include an indication that NCEP will support the NCEP co-investigator(s) to implement the new methodologies during the year following the project review, with operational implementation conditional on the review outcomes and at the discretion of NCEP.

Proposals are encouraged to include support for a team member to work at NCEP as a visiting scientist. Projects with this component must include in their proposal a timeline for the visit, the investigator role in the project, specification of an NCEP sponsoring staff member, a request for adequate travel resources, and a description of resources needed by the visitor along with a guarantee of provision by NCEP.

Proposals may be for a period of two years with a funding level of up to \$170k/yr.

**Competition Contact Information:**

MAPP Program Competition Manager: Heather Archambault ([heather.archambault@noaa.gov](mailto:heather.archambault@noaa.gov))

NGGPS Program Manager: Frederick Toepfer ([frederick.toepfer@noaa.gov](mailto:frederick.toepfer@noaa.gov))

CTB Acting Director: David DeWitt ([david.dewitt@noaa.gov](mailto:david.dewitt@noaa.gov))

---

---

<sup>23</sup> [http://cpo.noaa.gov/sites/cpo/Documents/pdf/MAPP\\_CT\\_B\\_Proposals\\_Requirements.pdf](http://cpo.noaa.gov/sites/cpo/Documents/pdf/MAPP_CT_B_Proposals_Requirements.pdf)

<sup>24</sup> [http://www.cpc.ncep.noaa.gov/products/ctb/meetings/2013/Metrics\\_climate\\_models&fcst\\_26July.pdf](http://www.cpc.ncep.noaa.gov/products/ctb/meetings/2013/Metrics_climate_models&fcst_26July.pdf)

## General Guidelines for FY 2018 MAPP proposal submission for all competitions

- Principal Investigators submitting a proposal in response to this MAPP Announcement are required to follow the Letters of Intent (LOI) and Proposal preparation and submission guidelines described in the Climate Program Office FY 2018 Federal Funding Opportunity announcement.
- Investigators are strongly encouraged to submit an LOI prior to developing and submitting a full proposal. MAPP Program LOI should be emailed to [oar.cpo.mapp@noaa.gov](mailto:oar.cpo.mapp@noaa.gov). Investigators will be notified by the MAPP Program as to whether a full proposal is encouraged based on the LOI within 30 days of the LOI due date.
- Proposals must clearly identify in their summary which one of the above-listed MAPP competitions is being targeted (only one competition may be targeted by a given proposal) and which sub-element of the competition is being targeted, if applicable.
- Administrative questions regarding the Federal Funding Opportunity (e.g. proposal formatting or submission guidelines) should be directed to Diane Brown ([diane.brown@noaa.gov](mailto:diane.brown@noaa.gov)).

### Computational Resources

Computational resources on NOAA's high-performance computing platforms may be requested for research sponsored as a result of this solicitation. Proposals should indicate the availability of alternative computing resources should NOAA resources not be available for the project. Proposers who choose to request computational allocations on NOAA's platforms must include in their proposal a request describing the computational resources and data storage required, as well as a description of how they will port their methodology to the NOAA platforms. Proposers must submit an [HPC Request Form](#) with their proposal in order to apply for computational resources<sup>25</sup>.

Questions regarding the use of NOAA's high-performance computing platforms should be directed to Dan Barrie ([daniel.barrie@noaa.gov](mailto:daniel.barrie@noaa.gov)).

### Data Management Guidance

Responsible NOAA Officials for questions regarding this Data Management Guidance and for verifying accessibility of data produced by funding recipients are as follows:

Competitions 1 and 3: Heather Archambault ([heather.archambault@noaa.gov](mailto:heather.archambault@noaa.gov))

Competition 2: Daniel Barrie ([daniel.barrie@noaa.gov](mailto:daniel.barrie@noaa.gov))

Data Accessibility: The MAPP Program requires that public access to grant/contract-produced data be enabled in one of the following ways (select one):

- ☐ Funding recipients are planning to submit data to NOAA National Centers for Environmental Information (NCEI), which will provide public access and archiving<sup>26</sup>. Point of Contact for NCEI is Nancy Ritchey ([Nancy.Ritchey@noaa.gov](mailto:Nancy.Ritchey@noaa.gov))

---

<sup>25</sup> [http://cpo.noaa.gov/sites/cpo/Documents/word/MAPP\\_FY18\\_HPC\\_Request\\_Form.docx](http://cpo.noaa.gov/sites/cpo/Documents/word/MAPP_FY18_HPC_Request_Form.docx)

<sup>26</sup> NCEI supports the creation of adequate metadata and data ingest into long term repository holdings using tools such as Send2NCEI ([www.nodc.noaa.gov/s2n](http://www.nodc.noaa.gov/s2n), for small volume, one-time only data collections) and Advanced Tracking and Resource tool for Archive Collections or ATRAC ([www.ncdc.noaa.gov/atrac](http://www.ncdc.noaa.gov/atrac), for recurring and/or large volume data collections).



- ❑ Data are to be submitted to an International Council for Science (ICSU) World Data System facility: <https://www.icsu-wds.org/community/membership/regular-members>)
- ❑ An existing publicly accessible online data server at the funded institution is to be used to host these data (describe in proposal).
- ❑ Data are to be submitted to a public data repository appropriate to this scientific domain (describe in proposal).
- ❑ Proposal may request permission not to make data publicly accessible (proposal to explain rationale for lack of public access, and if funded approval to be obtained from Responsible NOAA Official listed above).
- ❑ Archival of data at an established Cloud Computing facility, if cost effective and reliable

#### Technical recommendations:

The MAPP Program requires the following data format(s), data access method(s), or other technical guidance:

- Model data must be made available in a common machine-readable non-proprietary format with appropriate metadata and clear labels and descriptors. Use of netCDF is encouraged, and PIs can consider using CMIP5 output requirements as a guide for creating accessible datasets<sup>27</sup>.
- Data should be available via public and discoverable data portals, as described above.
- At a minimum, investigators should plan to archive and make available model data used in producing any figures in publications from research supported by their grants, as well as data that support conclusions reached in papers or stated publically. Only those data which are necessary for demonstrating reproducibility of published results need be archived and made public unless otherwise required as part of the solicitation.
- Model data should be made available for at least 3 years after it is initially published or made otherwise publicly available.

#### Resources:

Proposals are permitted to include the costs of data sharing and/or archiving in their budgets within solicitation specified proposal cost limit, and may include additional costs of up to \$30K, unless otherwise stated in the solicitation, if the total data volume is expected to exceed 10TB. Justification should be provided for why data volume is expected to exceed this limit, according to compliance with the technical recommendations given above. Proposed methods and approaches should use reasonable means to minimize data management costs.

---

<sup>27</sup> [http://cmip-pcmdi.llnl.gov/cmip5/docs/CMIP5\\_output\\_metadata\\_requirements.pdf](http://cmip-pcmdi.llnl.gov/cmip5/docs/CMIP5_output_metadata_requirements.pdf)

**Appendix** - Readiness Levels (from NAO 216-105B). Readiness levels are defined as a “systematic project metric/measurement system that supports assessments of the maturity of R&D projects from research to operation, application, commercial product or service, or other use and allows the consistent comparison of maturity between different types of R&D projects.”

<b>Mission Function</b>	<b>RL #</b>	<b>Readiness Level Definition</b>
<b>Research</b>	<b>1</b>	Basic research, experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a range of future applications
	<b>2</b>	Applied research: original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives.
<b>Development</b>	<b>3</b>	Proof-of-concept for system, process, product, service or tool; this can be considered an early phase of experimental development; feasibility studies may be included.
	<b>4</b>	Successful evaluation of system, subsystem, process, product, service or tool in laboratory or other experimental environment; this can be considered an intermediate phase of development.
	<b>5</b>	Successful evaluation of system, subsystem process, product, service or tool in relevant environment through testing and prototyping; this can be considered the final stage of development before demonstration begins.
<b>Demonstration</b>	<b>6</b>	Demonstration of a prototype system, subsystem, process, product, service or tool in relevant or test environment (potential demonstrated).
	<b>7</b>	Prototype system, process, product, service or tool demonstrated in an operational or other relevant environment (functionality demonstrated in near-real world environment; subsystem components fully integrated into system).
	<b>8</b>	Finalized system, process, product, service or tool tested, and shown to operate or function as expected within user's environment; user training and documentation completed; operator or user approval given.
<b>Deployment</b>	<b>9</b>	System, process, product, service or tool deployed and used routinely.